

Conference Paper

Granite Dust is the Possible Component of the Dry Construction Mixtures

Gerasimova Ekaterina¹, Kapustin Fedor¹,
Rogante Massimo², and Kochnev Dmitriy¹

¹Institute of new materials and technologies, Ural Federal University, Yekaterinburg, Russia

²Rogante Engineering Office, Civitanova Marche, Italy

Abstract

This paper is devoted to research of possibility of utilization of granite dust. It is shown that the granite dust from the crushing screenings of "Shartashskiy stone-crushed stone quarry" can be recommended as a filler for the production of dry building mixes for flooring. With the introduction of dust in the amount of 20 % by weight of cement it is possible to obtain the mortar of the class not less B12.5.

Keywords: Granite dust, dust-like waste, Portland cement, polymer, modification, compressive strength, flexural strength, sand, dry mixture, mortar, composition

Corresponding Author:

Gerasimova Ekaterina; email:
e.s.gerasimova@urfu.ru

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1. Introduction

Rocks and natural stone are the most common resources used for the production of building materials. Granite is one of the most widespread rocks among the main metamorphic ones used in construction. This is one of the most common rocks in the earth's crust.

Granite is an acidic rock consisting of quartz (20-40 %), potassium feldspar of orthoclase (40-70 %) and muscovite mica, or more often biotite (5-20 %). Due to high content of orthoclase granite color is mostly grey, bluish grey, dark red. Granite has a granular-crystalline structure, specific gravity – 2600-2700 kg/m³, compressive strength from 100 to 250 MPa and higher. Granite that contains more quartz and less mica has better construction properties. In Russia there are quite large reserves of granite, and their deposits located on the Kola Peninsula, in Karelia, in the Urals, Siberia, on coast of Azov Sea, in the Crimea, in the Caucasus.

Granite of different deposits has the different physical and mechanical properties, and processing of rock into coarse aggregate and other products is accompanied by formation of significant amounts of waste despite of economic and technological advantages during production and use of granite rock. For example, up to 25-30 % of screenings from crushing granite is produced during the manufacturing of coarse aggregate [1].

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In addition, the granite dust (GD) with a grains size less than 0.16 mm is formed when screenings screening on narrow fractions in production process of graded sand as well as during working of dust collection systems of crushing and screening equipment. In accordance with Russian Standard 31424-2010 "Non-metallic construction materials from sifting of crushing solid stone in aggregate manufacturing. Specifications" it can be classified as a dust component of crushing and screening process and it is recommended to be used as a filler in the building materials manufacture.

The using of granite dust mentioned above as a filler for concretes, mortars and dry construction mixtures of various purposes is a promising direction of this waste recycling. This may reduce the cost of products by decreasing the cement consumption and partially may solve the environmental problems of large-tonnage wastes formation from non-metallic building materials production.

There are many work devoted to utilization of silica fume, fly ash, slag and etc. in manufacturing of concretes, mortars and composite cements [2-5]. And only some studies [6-8] are devoted to the problem of recycling of granite crushing waste. [7] considers the possibility of using of crushed granite dust-like fractions as a filler for heavy cement concrete and it is found that the addition of GD improves the compressive and flexural strength of concrete and reduces cement consumption up to 10 %. The possibility of granite screenings using as a mineral additive to cement Kalashnikov's works is considered. The obtaining of effective high-mobility concrete mixtures based on granite crushed stone and super plasticizer S-3 with introduction of filler (waste of limestone mining and processing) was proved in [8]. However in general the use of dust-like waste is limited due to lack of practical recommendations on their application.

2. Experimental Program

In connection with the actuality of this issue the possibility of GD using in the composition of cement mortar was studied at the Department of materials science in the construction of the Ural Federal University with the help of Rogante Engineering Office. The raw materials are following: Portland cement CEM I 32.5, natural sand class II, in accordance with the fineness modulus – 1.8 belonging to the group of small sand, redispersible polymer powder PAV-22 on the basis of vinyl acetate and dust from the granite crushing screenings of "Shartashskiy stone-crushed stone quarry" (Sverdlovsk region).

Fractional composition of GD was studied by method of laser diffraction. It is uneven: about 16 % of the dust is represented by particles smaller than 10 μm , 18 % are 10-30 μm , and 33 % – 30-100 μm and 33 % 100-400 μm (Figure 1). It is observed three-modal

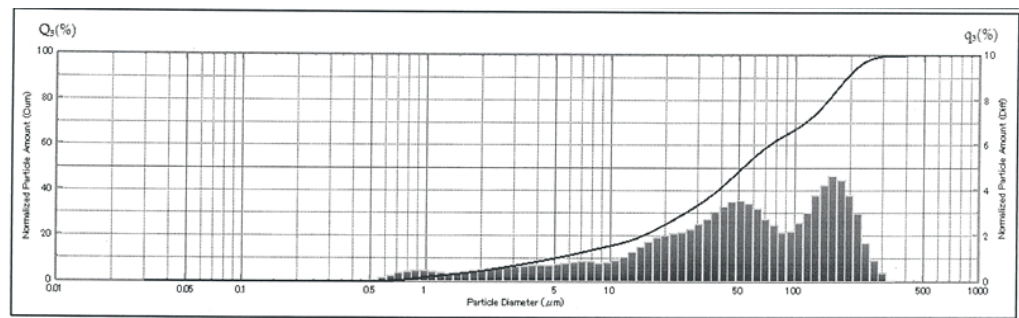


Figure 1: Fractional composition of granite dust.

distribution on the fractional composition, particles of 21, 54 and 170 μm size are more than other in the composition of the filler.

3. Results and Discussion

Firstly the influence of GD additives on the properties of cement paste and stone was studied. The mixtures of the same mobility were prepared in which cement was replaced with GD in an amount of from 5 to 30 % by weight. In parallel control mixture that does not contain GD was prepared. It was found that GD has water reducing effect, reducing the water demand of the same mobility mixtures about 40 % with increasing quantity of the filler up to 30 % (Figure 2).

The compressive strength of cement stone with a 10 % dust (hardening in normal conditions) is comparable with the strength of pure cement stone not containing a filler because of the structure densification of cement stone. Other compositions' strength is less by 30 % on average (Figure 3). The introduction of GD slightly increases the cement stone flexural strength. Perhaps the presence of the dispersed grains of a certain size contributes to the formation of stronger linkages and contacts which play a significant role to the flexural strength increase. These data are agreed with the results of Estrin's study.

Thus, it is found that replacement of 10 % cement by GD doesn't reduce the compression strength of cement stone and increases the flexural strength. It can be assumed that for the production of finishing dry mixes, for which more important characteristic is flexural strength, the quantity of GD in the mixture can rationally be increased to 15-20 %.

Dry mixes are polydisperse mixture which consists of many components, and polymeric additions are necessary component. The simultaneous influence of GD and polymer powder upon the strength of the cement mortar has been studied by the mathematical planning method. This stage of the work was carried out by using the full factor experiment (type 2^2) planning method. The factors are as following: the quantity of

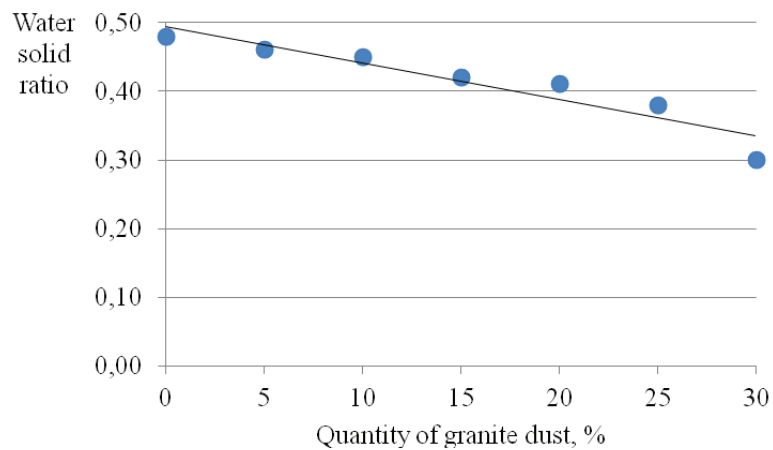


Figure 2: The influence of the granite dust on water requirement of cement paste.

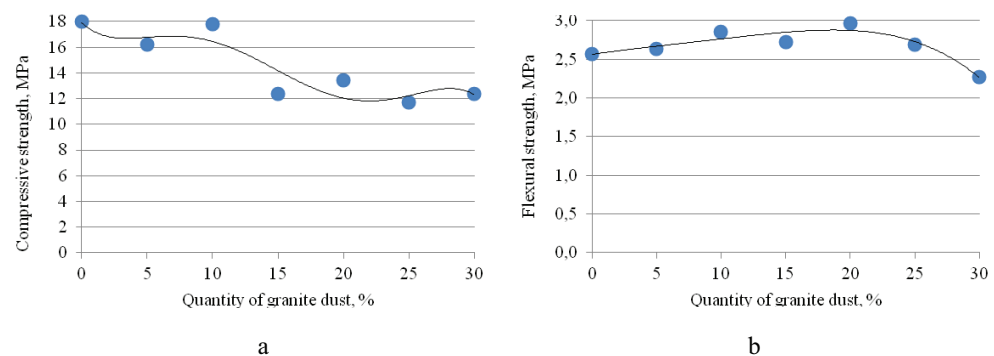


Figure 3: The influence of the granite dust on the compressive (a) and flexural (b) strength of the cement stone.

granite dust by weight of cement (X_1), and the quantity of PAV-22, introduced extra of the weight of cement (X_2) (Table 1). Variability intervals of the factors were chosen according to the results of the preliminary work. In accordance with the experiment plan mixtures of the same mobility were prepared, samples-cubes with edge of 7 cm were formed from them. The samples were tested at the age of 1, 3, 7, 14, 21 and 28 days after hardening in air-wet conditions.

It is found that in the presence of a polymer powder, the mortar strength is maintained at a high level even with the presence of 20 % GD (Table 2, Figure 4). Apparently, the contribution of polymer films distributed in the structure of cement-sand-stone

| Factor | Symbol | Interval | Meaning at levels | |
|-----------------------|--------|----------|-------------------|----|
| | | | +1 | -1 |
| Quantity of GD, % | X_1 | 10 | 20 | 10 |
| Quantity of PAV-22, % | X_2 | 2.5 | 2.5 | 0 |

TABLE 1: Experimental plan.

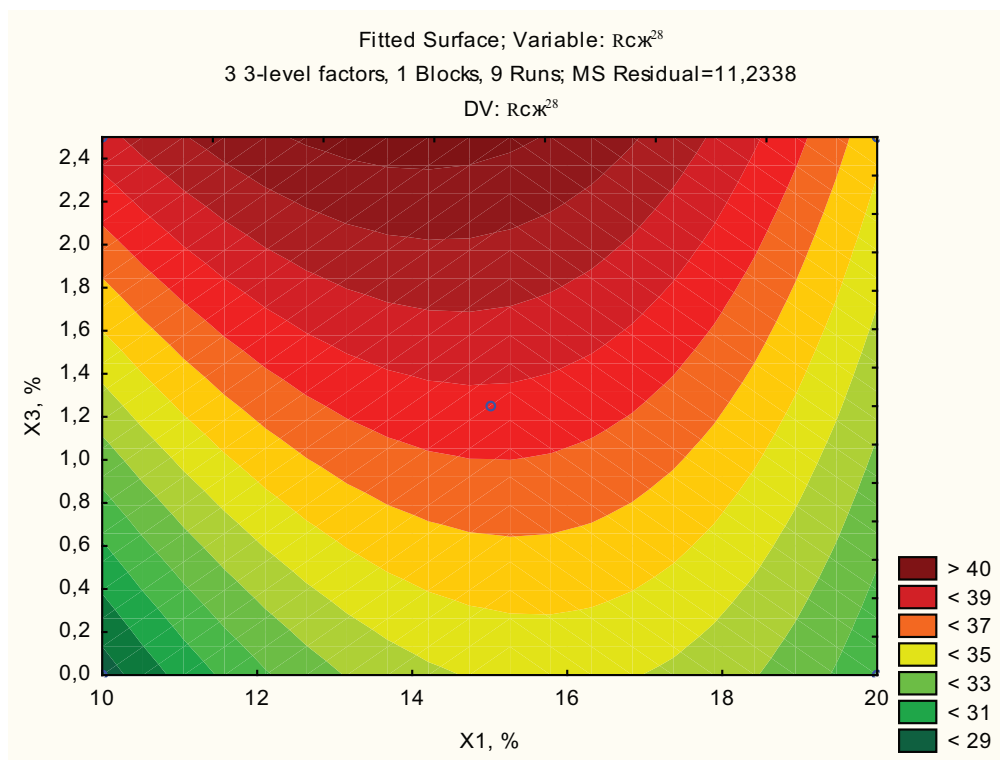


Figure 4: The projection of curvilinear compressive strength dependence of the mortar (28 days age).

| Mix № | Quantity, % | | Compressive strength, MPa, age, days | | | | | |
|-------|--------------|--------|--------------------------------------|------|------|------|------|------|
| | granite dust | PAV-22 | 1 | 3 | 7 | 14 | 21 | 28 |
| 1 | 20 | 2.5 | 8.0 | 21.1 | 24.7 | 32.3 | 35.6 | 36.4 |
| 2 | 10 | 0 | 9.2 | 16.0 | 24.2 | 27.2 | 28.9 | 29.6 |
| 3 | 20 | 0 | 7.3 | 13.0 | 21.5 | 26.0 | 28.8 | 30.0 |
| 4 | 10 | 2.5 | 6.6 | 18.8 | 31.1 | 33.4 | 35.2 | 37.4 |

TABLE 2: The kinetics of compressive strength development of the mortar.

in to the strength indexes is significant. It can also be related to improvement of aggregate stability of the polymer addition in the alkaline environment of Portland cement. Granite dust dilutes the Portland cement in the composition of the mortar and contributes to more stable and durable polymer films.

On the basis of the results obtained as the basic composition for the dry construction mixture production first composition with a maximum content of GD and RPP PAV-22 and the ratio of finely dispersed component (cement and GD) to sand equal to 1:3 was selected.

Indicators of dry building flooring cement binder mixes are regulated by Russian standard 31358-2007. The mixture of base composition with mobility equal to 11 cm of standard cone and the water requirement of 70 % was prepared. Then beam-samples

| Indices | Base composition | Requirements of Russian standard 31358-2007 |
|---|-------------------------|---|
| Humidity, % | 0.1 | ≤ 0.2 |
| Dmax, mm | 2.5 | ≤ 5.0 |
| Quantity of grains of Dmax, % | 2.8 | ≤ 5.0 |
| Persistence of initial mobility, min | ~40 | ≥ production time |
| Water-holding capacity, % | 95 | ≥ 95 |
| Rfl / Rcom, 3 days, MPa | 4.3 (46 %) / 9.7 (49 %) | ≥ 30 % of design strength |
| Rfl / Rcom, 28 days, MPa | 9.3 / 19.6 | B _{tb} 5.2 – 7 / B12.5 – 16 |
| Abradability, g/sm ² | 0.03 | ≤ 0.8 |
| Adhesion strength of the mortar with a concrete base at the age of 28 days, MPa | 0.79 | ≥ 0.6 |
| Shrinkage deformation, mm/m | 0.19 | ≤ 1.0 |

TABLE 3: Characteristics of the mixture and mortar.

were formed and tested according to Russian standard 31356-2007. Characteristics of the mixture and mortar are given in Table 3.

It is stated that indices of the dry mixture, mix ready-to-use and mortar meet the requirements of Russian standard. Class of mortar according to compressive strength is B12.5 and according to flexural strength – B_{tb}5.2. The adhesion strength of the mortar with a concrete base at the age of 28 days is equal to 0.79 MPa which is more than the required value by 30 %. However, the fracture type of mortar in adhesion determining corresponds to the “cohesive separation on the sample body”, which indicates the low value of adhesion when tested.

4. Conclusion

The result of this work, it is established that the granite dust from the crushing screenings of “Shartashskiy stone-crushed stone quarry” can be recommended as a filler for the production of dry building mixes for flooring. With the introduction of dust in the amount of 20 % by weight of cement it is possible to obtain the mortar of the class not less B12.5.

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